

# CNG Infrastructure: Best Practices Guide for Host Sites and Local Permitting Authorities

*Prepared for:*  
*The California Statewide Alternative Fuel and Fleets Project*  
*By*  
*Clean Fuel Connection, Inc.*



# Agenda

- Fueling and Infrastructure Needs
- Ownership Models and Financing
- Return on Investment (ROI) Models
- Station Design and Specifications
- Capital Costs
- Codes and Permitting
- Construction and Commissioning
- Operating Costs
- Resources



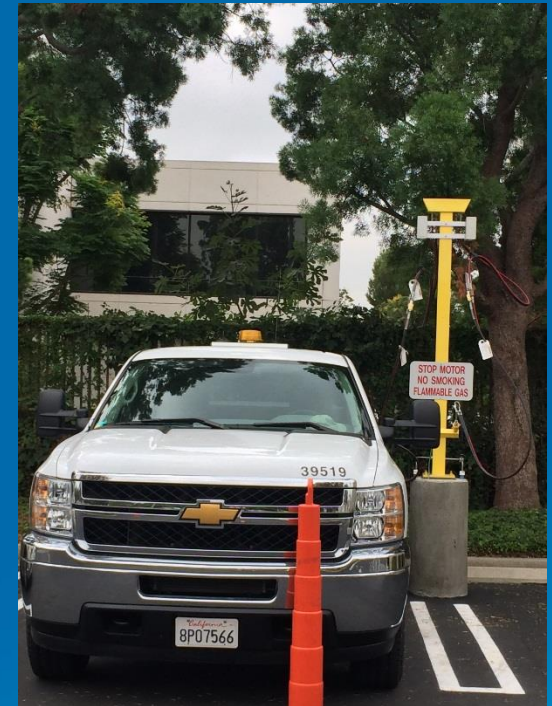
# Determining Fueling and Infrastructure Needs

- What are the daily distances travelled?
- Duty cycle—does the vehicle return to base overnight?
- Time available for refueling—can the vehicles be filled overnight or do they need to be fast-filled (similar to a gas station)?
- What are the economics of building a station vs. using public infrastructure (if available)?
- Public vs. private access—will there be public access to the station?



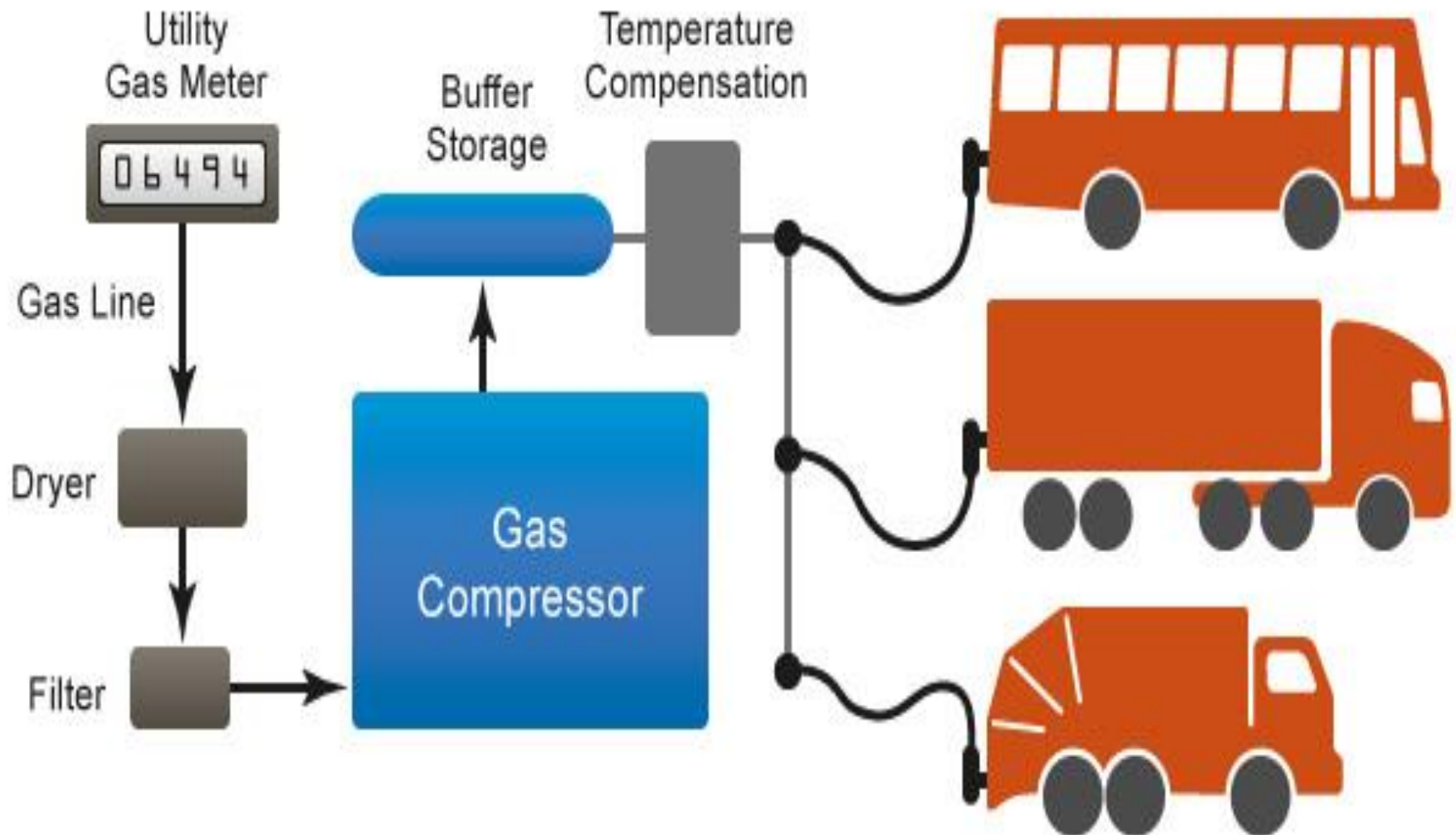
# Types of Fueling

- Time fill only
- Fast fill with cascade storage
- Fast fill with buffer storage
- Combination time fill and fast fill

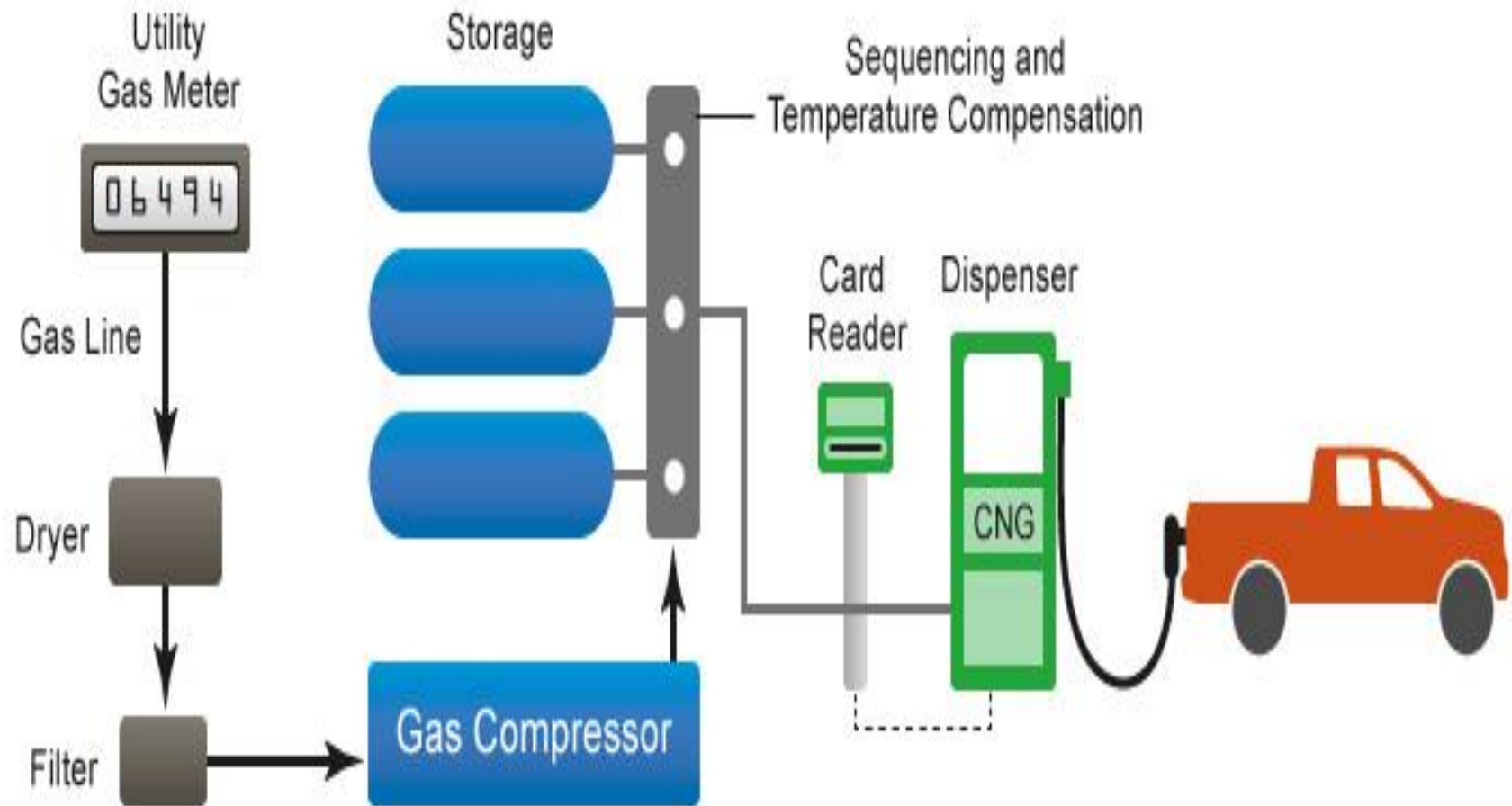


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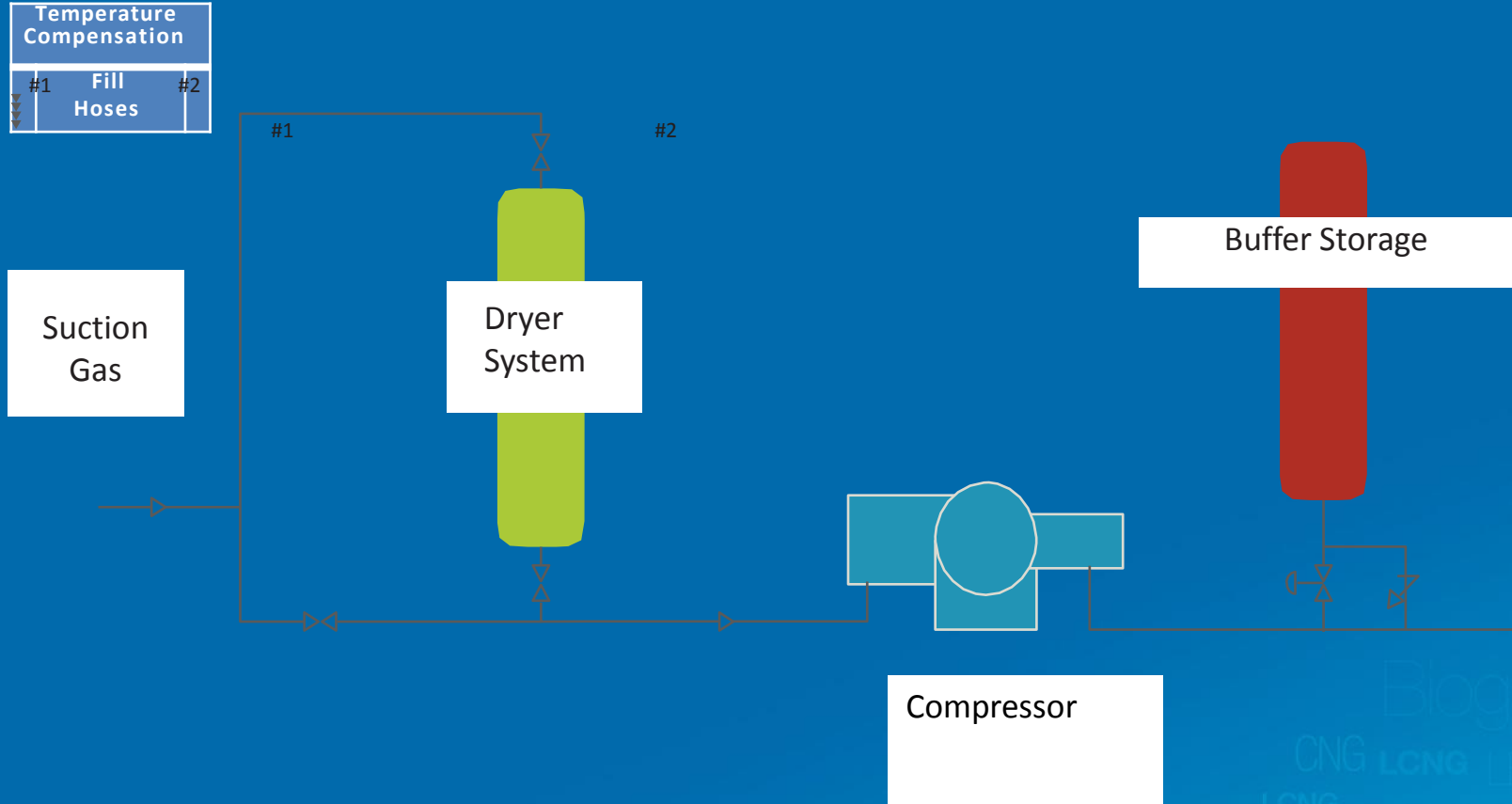
# Time-Fill Station



# Fast-Fill Station



# Buffered Fast-Fill System



# Calculating Station Size

INLET PRESSURE						AMBIENT TEMPERATURE							
MAXIMUM				45	PSIG	MAXIMUM				100	°F		
NORMAL				60	PSIG	NORMAL				55	°F		
MINIMUM				80	PSIG	MINIMUM				-10	°F		
AVERAGE VEHICLE REFILLING						EXPECTED FLOW RATE							
Type				Capacity									
Light Vehicles				8GGE		SCFM				394			
Medium Vehicles				20GGE		GGE				3.1			
Heavy Vehicles				90GGE									
Daily Demand	Time	0 AM	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM
	Light								5				3
	Medium							2					
	Heavy						2						
	Demand	0	0	0	0	0	10	40	40	0	0	0	24
	Time	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM
	Light					10							
	Medium				5								
	Heavy			2					2				
	Demand	0	0	180	100	80	0	0	180	0	0	0	0
	TOTAL DAILY DEMAND											824	GGE



# Time Required to Fill Fleet

	Inlet Pressure 60 psi	Flow (scfm)	GGE/day/ truck	No. of trucks	Total GGE/day	SCFM per day	<a href="#">gge/min</a>	minutes to fill one vehicle (fast fill)	minutes to fill two vehicles at once (fast fill)	Hours to fill 30 vehicles (time fill)
Small Compressor (60 HP)	60	84	12	45	540	67500	0.672	17.9	35.7	13.4
Large Compressor (200 HP)	60	616	12	45	540	67500	4.928	2.4	4.9	1.8

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LNG Biogas  
CNG LBG  
Biogas LBG

# Typical CNG Station Components

- Compressor (IMW, Ariel, Bauer, Ingersoll Rand)
- Dispenser with point of sale or fuel management system (Greenfield, Gilbarco, Wayne-Dresser)
- Time-fill posts for overnight fueling
- Fast fill post without point of sale or fuel management (for private fleet applications)



# Typical CNG Station Components

- Dryer removes moisture from gas—can automatically dry desiccant or require manual replacement (Xebec)
- Storage (ASME (American Society of Mechanical Engineers) certified vessels by various manufacturers)
- Priority panel (controls the storage vs. compressor sequencing)
- Program logic controller (controls the compressor parameters)
- Sequencing Panel—controls flow from storage



# Ownership and Financing Models

1. End user owns and operates
2. Third party owns and operates at your site
3. End user owns and contracts with third party to operate
4. Finance through equipment leasing
5. Compression rental services (private)
6. Compression services tariff  
(So Cal Gas)



# Public and Private Options

	Private Access	Public Access
On site (end-user fleet)	X	X
Off site (fuel provider)	X	
Public station		X



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# Return on Investment Models

- There are a number of resources available to help project capital costs, operating costs, revenues and return on investment
- VICE--Vehicle and Infrastructure Cash Flow Evaluation Model—comprehensive model for calculating capital and operating costs of vehicles and infrastructure

[www.afdc.energy.gov/fuels/natural\\_gas\\_infrastructure.html](http://www.afdc.energy.gov/fuels/natural_gas_infrastructure.html)



# America's Natural Gas Alliance Compressed Natural Gas Infrastructure Report

	Actual Onsite Government Fleet21	Actual LDC	Actual Existing Retailer	Hypothetical Independent Retailer
Capital Costs, Excluding Land				
Size of Station (cfm)	250	700	150	<b>700</b>
Total Non-Land Capital Cost (\$)	1,000,000	800,000	650,000	<b>800,000</b>
Less: Incentives (\$)	0	175,000	250,000	<b>175,000</b>
Net Capital Costs (\$)	1,000,000	625,000	400,000	<b>625,000</b>
Estimated Salvage Value @ 15% (\$)	150,000	120,000	97,500	<b>120,000</b>
Net Present Value of Salvage Value (\$)		80,757	30,736	<b>37,829</b>
Annual Operating Costs, including fuel taxes				
Total Expenses, Including Motor Fuels Taxes (\$)	198,181	424,885	269,907	<b>563,127</b>
Annual Revenues/Sales				
Total Quantity Gas Sold (GGE)	90,454	315,000	150,000	<b>315,000</b>
Price at Pump, Including Taxes (\$/GGE)	2.19	1.56	1.92	<b>2.50</b>
Total Revenue (\$)	198,181	491,400	288,000	<b>787,500</b>
Annual Net Income (\$)	0	66,515	18,093	<b>224,373</b>
ROI	<b>0.0%</b>	<b>10.6%</b>	<b>4.5%</b>	<b>35.9%</b>

# Station Design and Specifications

- Critical Factors

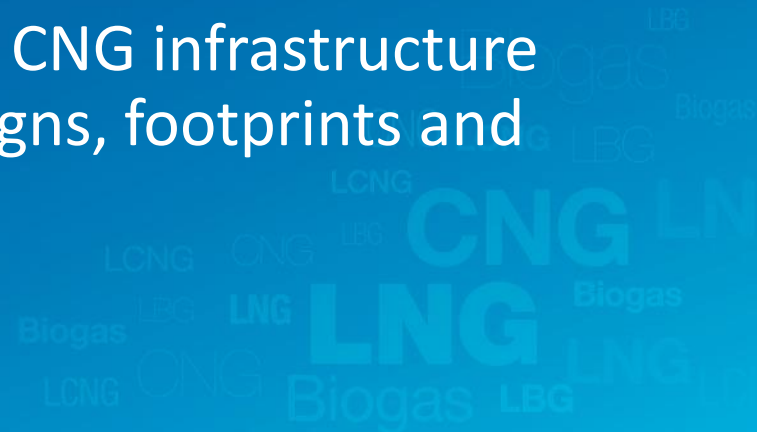
- Location of the gas utility's distribution line and the inlet pressure at the site
- Throughput or demand for fuel
- Building and electrical codes
- Intended use (fleet only or public)
- Time Fill or Fast Fill
- Capital and Operating Budget
- Local zoning





# Resources for Station Design

- Experienced consultants or engineers
- Manufacturers and integrators
- Industry Organizations
  - Natural Gas Vehicle Association
  - Natural Gas Vehicle Institute (training)
  - The Drive Natural Gas Initiative of America's Natural Gas Alliance
  - The American Gas Association ( CNG infrastructure guide that includes sample designs, footprints and typical costs)



# Capital Budgets

- Typical Capital Costs Equipment
  - Smaller station --\$100k to \$300k
  - Larger station--\$500k to \$1 million
- Installation Costs
  - Variable depending on site conditions, power, access to gas line, local requirements
  - \$150,000 to \$500,000+



# CAPITAL COST EXAMPLE FROM ANGA CNG INFRASTRUCTURE GUIDE

Component	Estimated Costs, \$
Gas Supply Line	20,000 - 150,000
Compressor Package	200,000 - 400,000
Noise Abatement	0 - 40,000
Gas Dryer	50,000 - 80,000
Storage (3 or 6 ASME)	100,000 - 200,000
Dispenser (1 or 2 00M-hose)	60,000 - 120,000
Card Reader Interface	20000- 30,000
Engineering	25,000- 75,000
Construction	300,000 — 600,000
Contingencies	10 — 150,000
Estimated Total (Excludes, land cost)	805,000 – 1,845,000

# Example from ANGA CNG Infrastructure Guide

	Fast Fill Station I:	Fast Fill Station II:	Time Fill Station:
	Natural gas dryer, one 300 scfm compressor, 3 ASME vessel high-pressure storage systems, 1 two- hose fast-fill dispenser (no redundancy)	Natural gas dryer, two 300 scfm compressors, 3 ASME vessel high-pressure storage systems, 1 two-hose fast-fill Dispenser (with redundancy)	Natural gas dryer, one 300 scfm compressor, 20 two-hose, time-fill dispensers (no redundancy)
<b>Component Cost</b>	\$500,000	\$650,000	\$375,000
<b>Installation Cost*</b>	\$300,000	\$350,000	\$300,000
<b>Total Cost</b>	\$800,000	\$1,000,000	\$675,000
<b>Vehicle Fueling Scenarios</b>	<p>15 light-duty/15GGE consecutively fueling in a 1-hour peak period or randomly arriving light-duty/10 GGE</p> <p>or</p> <p>10 heavy-duty/20 DGE consecutively fueling in a 1-hour peak period or randomly arriving heavy-duty/DGE</p>	<p>15 light-duty/15 GGE consecutively fueling in a 1-hour peak period or randomly arriving light-duty/10 GGE</p> <p>or</p> <p>10 heavy-duty/20 DGE consecutively fueling in a 1-hour peak period or randomly arriving heavy-duty/10 DGE</p>	<p>40 vehicles/38 GGE in a 10-hour period</p> <p>or</p> <p>40 vehicles/33 DGE in each vehicle in a 10-hour period</p>

# Codes and Permitting

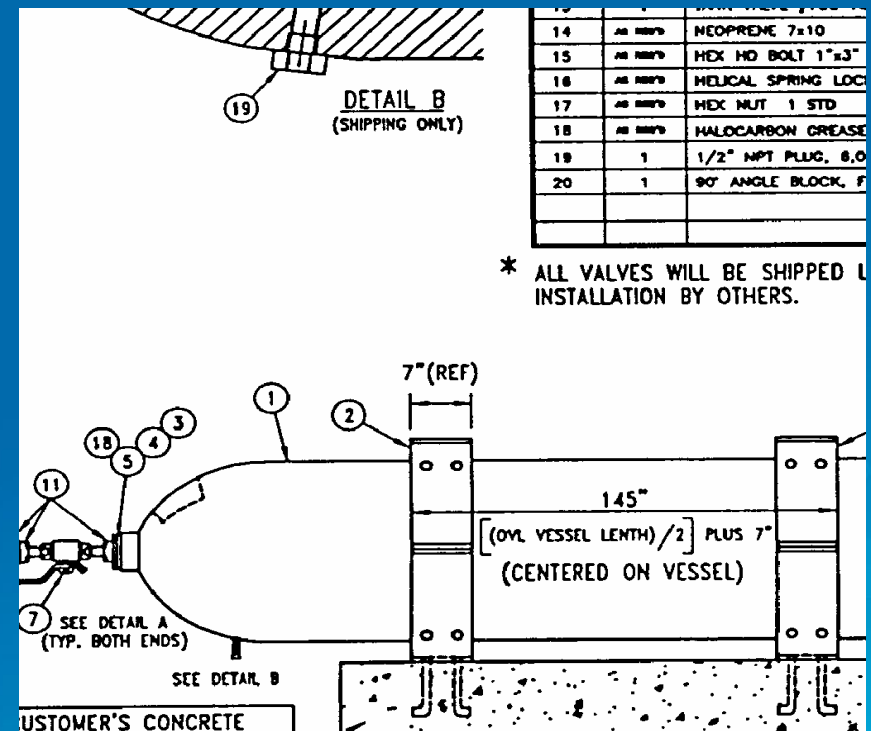
The primary code for CNG fueling is NFPA 52 which is described as follows:

*Provisions cover the design, installation, operation, and maintenance of CNG and LNG fuel systems on all vehicle types--plus their respective compression, storage, and dispensing systems. (Current version 2013)*

- Other Important Codes include:
  - NFPA 70—National Electrical Code
  - NFPA 55--Compressed Gases and Cryogenic Fluids Code (sections related to CNG are included in NFPA 52)
  - FMVSS (DOT) 304 Compressed Natural Gas Container Integrity
  - Uniform Building Code (UBC)
  - Uniform Plumbing Code (UPC)
  - ASME B31.3 (Plumbing)
  - ASME (section 8)
- There are also some California-specific codes that need to be following including:
- Uniform Building Code (UBC)-- Seismic Zone 4—for footings, founding and soil for dryer, compressor and storage vessels
  - UBC must meet wind requirements up to 70 miles per hour for dryer, compressor and storage vessels
- CAL-OSHA Title 8 Article 7 Unfired Pressure Vessel Code for safety for pressure Vessels (CNG storage containers)

# Permitting

- Check for proper zoning
- Stations require approval by Fire Dept, Community Development and Building *at a minimum*
- Involve the local utility  
--So Cal Gas
- Start early



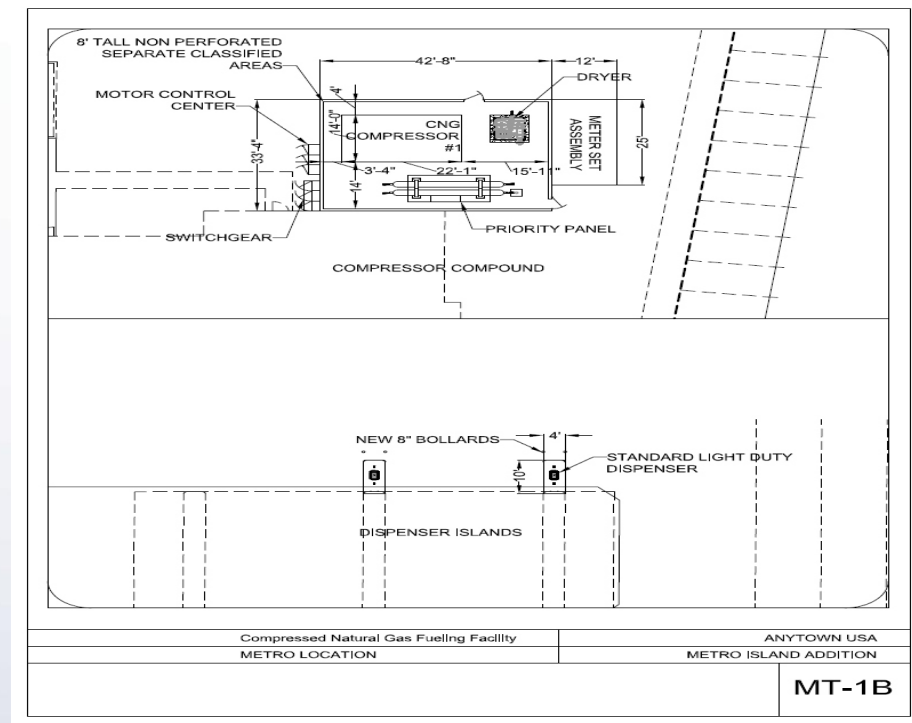
# Construction and Commissioning

- Construction tasks include:
  - Concrete pads for equipment
  - Utility Meter set
  - Connections between meter, compressor, dryer, storage, priority control panel and dispenser
  - Electrical service
- Commissioning tasks include:
  - Final terminations of wires
  - Testing of all components
  - Final City sign-off



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# SAMPLE STATION DESIGN FROM ANGA CNG INFRASTRUCTURE GUIDE





# Operating Costs

- VICE Calculator can help estimate costs
- Electricity
- Consumables such as filters and oil
- Maintenance
- Planned Service
- Unplanned Service
- Commodity



# Example for ANGA CNG Infrastructure Guide

Annual Operating Costs, including fuel taxes				
Natural Gas Cost (\$/GGE) (Including Transportation and Local Distribution)*	0.87	0.72	0.68	0.68
Total Natural Gas Cost (\$)	79,147	226,800	102,000	214,200
Electricity Cost (\$/GGE)		0.06	0.25	0.13
Total Electricity Cost (\$)		18,900	37,500	18,900
Equipment Maintenance/Administration (\$)		56,700	30,000	63,000
Marketing (\$)				50,000
Insurance (\$)				25,000
Credit Card Fees (\$)			8,640	23,625
Federal Tax at \$ 0.184/GGE (\$)	None	57,960	27,600	57,960
State Tax (\$)	None	26,775	12,000	26,775
Depreciation Expense (\$)	42,500	25,250	20,167	33,667
Interest Expense/Cost of Capital (\$)	20,000	12,500	32,000	50,000
All Other Expenses (\$)	56,534			
Total Expenses, Including Motor Fuels Taxes (\$)	198,181	424,885	269,907	563,127

# Resources

- VICE Model--  
[www.afdc.energy.gov/fuels/natural\\_gas\\_infrastructure.html](http://www.afdc.energy.gov/fuels/natural_gas_infrastructure.html)
- CNG Infrastructure Guide for the Prospective CNG Developer—ANGA
- A Recommended Permitting Guide for Compressed Natural Gas Fueling Stations (10 years old and focuses on Northeast but short and detailed on codes)
- Recommended Practices for the Design, Installation, Operation and Maintenance of Compressed Natural Gas Vehicle Fueling Facilities
- Costs Associated with Compressed Natural Gas Fueling Infrastructure—Clean Cities DOE



# Final Advice

- Do your homework
- Use the excellent resources available
- Start permitting early
- Consult with your gas utility
- Plan for future expansion
- Don't forget about maintenance and service



ance and service

# THANK YOU!

Enid Joffe

Clean Fuel Connection, Inc.

[enidjoffe@cleanfuelconnection.com](mailto:enidjoffe@cleanfuelconnection.com)

[www.cleanfuelconnection.com](http://www.cleanfuelconnection.com)

626 445-1445

